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being nicely balanced, the ecliptic and equator coincide. If now a small weight be fixed to the equatoreal disk, to represent the attraction of the sun and moon, or the axis be considerably inclined, which answers the same purpose, and the globe be rapidly rotated, representing the diurnal motion, it will be seen that at the same time there is generated a slow conical movement of the projecting axis round the imaginary pole of the ecliptic, in a direction opposite to that of the diurnal rotation; and that the equinoctial points, or intersections of the ecliptic and equator, move round in the same way."

The author remarks that, upon attentive observation, it will be found that the axis does not describe a perfect circle round the perpendicular to the ecliptic, but that there is a minute undulation resembling the nutation of the earth's axis.

"I am aware that the mechanical causes of the motions set up are not the same with the physical causes of the real motions of the earth, but the object was to obtain an imitation of the effect, regardless of the exact identity of mechanical causes. So far as I understand the description of Mr. Atkinson's instrument, there is, of course, an identity of principle and effect, but he seems to have had other points to illustrate, and only mentions precession as an incidental one; whereas, in my construction of the apparatus, those additions are made which enable it to carry out the imitation to the fullest extent; and having myself found it useful in explaining the motions referred to, I have thought a knowledge of it might be acceptable for a like purpose to other members of the Society. The drawings show the apparatus in perspective and section, and are sufficient, with the preceding description, to explain it without references."*

Note by the Editor.

In the *Edinburgh New Philosophical Journal* for April 1855 there is a paper by Mr. James Elliot, Teacher of Mathematics, Edinburgh, which also contains a description of an apparatus

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* Apparatuses for exhibiting the conical movement of the earth's axis, which occasions the precession of the equinoxes, have also been contrived by Bohnenberger, Fessel, and Professor Powell. They are all unexceptionable, both in principle and practice, and serve to represent the phenomenon with the most complete fidelity. This remark will appear superfluous to many persons, but it has been deemed necessary to advert to the circumstance in consequence of objections having been urged against those apparatuses, which could only arise from an imperfect knowledge of the mechanical principles of their construction. Nor can such objections be justified by referring them to an imperfect working of the apparatus in any case, since from the nature of the mechanism it is impossible that the axis of rotation, if it have a movement at all, should have any other than a conical movement. In all these contrivances (as in Atkinson's original apparatus, now in the possession of Mr. Riddle at Greenwich) there is an arrangement of great simplicity, by which the conical motion of the axis of rotation may be rendered *direct*, as exemplified by the spinning-top or *retrograde*, as in the case of the earth's motion, thus affording a most instructive view of the mechanical principles which determine the grand phenomenon of the precession of the equinoxes.—Editor.

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exactly the same as Atkinson's; but the author does not seem to be aware of the fact that any person had preceded him in the invention. The paper, which is entitled "A Description of certain Mechanical Illustrations of the Planetary Motion, accompanied by Theoretical Investigations relating to them, and in particular a new Explanation of the Stability of Equilibrium of *Saturn's* Rings," was read before the Royal Scottish Society of Arts on the 27th of February and 13th of March, 1854.* It contains several ingenious illustrations of the planetary movements in addition to that of precession. The author states that he was first led to consider the possibility of imitating the conical motion of the earth's axis by observing the whirling of a penny, and that afterwards, from reading Herschel's *Astronomy*, his attention was turned to the analogous movements of the te-to-tum and the top. "I observed, however," says he, "that in tops which have short pegs, this motion—the conical motion of the axis—is slower than in those which have long ones; and, in fact, the shorter the peg the slower the revolution. It therefore occurred to me, that if we could lower the centre of gravity till it coincided with the centre of motion, this movement would cease altogether, and the top would continue to spin with its axis pointing permanently in any direction in which it might be placed. I also concluded, if we still further extended the same change which gradually annihilated the positive motion, it would reappear negative or in the opposite direction. With that view I had an instrument constructed of the form showed in the annexed cut,† consisting of a wooden ball hollowed out in its lower part, so as to admit the support upon which it rests to be raised above the centre of gravity, and with a screw upon its peg or axis, to admit of its being raised or lowered at pleasure. I also confined it to one place, by forming a small cavity on the support for the point of the peg to run in. This being done, I was much pleased to find my expectations exactly realised. By adjustments of the screw the conical revolution could be quickened, retarded, annihilated, or reversed, as might be desired, and all its motions were brought under perfect control. At the same time it was surrounded by a fixed plane to represent the ecliptic, its own equator being marked upon it; and by forming the axis of hard steel and giving it a support of agate, its velocity could be kept up without much abatement for a long time.‡

"The rotation is produced in the ball by means of a string and handle, much in the same way as that in which a humming-top is spun. The case in which, from the two centres coinciding, the axis remains fixed in one direction without any conical revolution,

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* It is stated that the silver medal of the Society, value ten sovereigns, was awarded to the author on account of his paper.

† The drawing here alluded to is almost identical with that annexed to the preceding paper.

‡ The author here states in a note, that since the model described was constructed, his attention had been directed to Bohnenberger's instrument, of which he was not previously aware.

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enables us to illustrate clearly what is meant in astronomy by the parallelism of the earth's axis, since the model may be carried by the hand slowly round in any circular or elliptic orbit, without any perceptible deviation of the axis from its original direction. But when the centre of gravity is brought slightly below the point of support, we are then enabled to show the deviation from parallelism which arises in the direction of the earth's axis after a long period of years, the same motion exhibiting the precession of the equinoxes. With the centre of gravity so placed, if the ball is made to rotate in the direction marked by the upper arrow on the figure, or from west to east, the equinoctial point E is observed to move slowly in the direction marked by the lower arrow from east to west. The latter motion may be made as slow as we please, so as to approach within any degree of closeness the exceedingly slow precessional movement of the earth's equator."

In another part of his paper the author makes the following remark:—

"If we next load the sphere on one side *very slightly* by any means, we obtain an illustration of the nutation of the earth's axis, the axis making a multitude of minute conical revolutions round the circumference of the greater conical revolution."

Note on the Method of Computing the Moon's Parallax.
By Mr. Sang.

In deducing the true from the apparent place of a heavenly body, it is usual to correct the observed altitude for the effect of atmospheric refraction, and to use the altitude thus corrected as the argument for the parallax; the sine of the parallax being supposed to be proportional to the sine of the corrected zenith distance.

This operation is founded on the hypothesis, that on correcting the observed altitude for refraction we obtain that altitude at which the planet would have been seen from the observatory if there had been no atmosphere. This hypothesis, however, is incorrect, as is evident when we consider that the ray of light, impinging on the upper surface of the atmosphere, is gradually bent downwards, and reaches the eye after having traced a curved path through the air. The angle of refraction is that angle which the first direction of the light makes with its direction when just entering the telescope; and, therefore, on correcting the observed altitude for refraction we obtain the direction, not of the original unrefracted ray, but of a line drawn parallel to it through the place of observation, which line cannot pass truly through the planet.

Thus if A be the observatory on the earth's surface, M the position of a celestial body, and M B the ray of light entering the atmosphere at B and then describing the curved line B A, the